

## **Draft Proposed Sampling Program to Determine Extent of World Trade Center Impacts to the Indoor Environment**

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**BACKGROUND:** This proposal is the result of ongoing efforts to monitor the situation for residents and workers impacted by the collapse of the World Trade Center (WTC) towers. In March 2004, EPA convened an expert technical review panel to guide and assist the Agency in its use of available exposure and health surveillance databases and registries to characterize any remaining exposures and risks, identify unmet public health needs, and recommend any steps to further minimize the risks associated with the aftermath of the WTC attack.

The WTC Expert Technical Review Panel has met seven times in open meetings to interact with EPA and the public on plans to monitor for the presence of WTC dust in indoor environments and to suggest additional evaluations that could be undertaken by EPA and others to evaluate the dispersion of the plume and the geographic extent of environmental impact from the collapse of the WTC towers.

The panel was charged, in part, with reviewing data from post-cleaning verification sampling to be done by EPA in the residential areas included in EPA's Indoor Air Cleanup and to verify that recontamination has not occurred from central heating and air conditioning systems. With the assistance of Westat, a contractor in the field of statistics, EPA developed a sampling plan to evaluate whether apartments previously cleaned in EPA's Region 2 clean and test program had become recontaminated. The EPA proposed plan was debated by the panel, and most panel members believed that an alternate study to test for "contamination" rather than "recontamination" should be conducted instead.

Using a peer review contract, EPA solicited expert comment from non-panel experts on the use of asbestos as a surrogate for determining risk from other contaminants and provided a report on those comments back to the panel. The external reviewers generally supported the use of asbestos as a surrogate, but encouraged the concurrent testing for lead.

Many members of the panel did not support the position that asbestos was an appropriate surrogate in determining risk for other contaminants, and instead, discussions have led to the concept that a WTC signature exists in dust and that sampling could focus on determining the presence of that signature, as well as the levels of contaminants of potential concern. The current thought is that there could be a signature for both the dust generated by the collapse and dust generated by the fires which burned into December of 2001. Preliminary research, as described

below, suggests that signatures for both the collapse and the fire have been identified in outdoor dust samples, and efforts are underway to confirm their presence in the indoor environment.

The panel is reviewing the ongoing work by the federal, state and local governments and private entities to determine the characteristics of the WTC dust plume and where it was dispersed, including the geographic extent of EPA and other entities' monitoring and testing, and recommending any additional evaluations for consideration by EPA and other public agencies.

EPA developed an alternate sampling plan to evaluate the presence and levels of contaminants of potential concern in buildings in lower Manhattan, including contaminants that could be markers for WTC dust. A primary objective of this study will be to determine the geographic extent of WTC dust, and plans call for sampling beyond Canal Street to as far north as Houston Street in lower Manhattan. To the extent possible, the sampling results will also be used to determine the geographic extent and impact of the fire plume residues.

The following proposal replaces earlier draft proposals made by EPA. A cornerstone of this proposal is the existence of a reliable signature for WTC dust and/or combustion products.

**OBJECTIVES:** Concurrent efforts have the following objectives –

- (1) To estimate the geographic extent of WTC contaminants of potential concern (COPCs) resulting from the building collapse and fire plume by surveying residential and non-residential buildings in lower Manhattan that volunteer to participate. Sub-objectives will be to relate results of the survey to building cleaning history and to the role of central heating, ventilation, and air conditioning (HVAC) if the information collected will support such an analysis;
- (2) To provide the data necessary to determine if a Phase II sampling should proceed, which will test for the presence of collapse and fire plume residues in areas beyond the boundaries of the areas currently tested, and to provide the data necessary to determine whether and what further actions are warranted; and
- (3) To validate a method to identify a signature for WTC dust and/or combustion products.

## **APPROACH:**

### **I. GEOGRAPHIC EXTENT SURVEY**

**A. Overview:** The primary objective of this sampling program will be to estimate the geographic extent of WTC collapse and fire plume residues in a sample of buildings that volunteer to participate. Success in meeting this objective is contingent on developing a “signature” for WTC dust residue and the availability of a sufficiently large list of candidate buildings (referred to as the ‘sample frame’) to provide sufficient coverage of the area to be

studied. If sufficient volunteers are not forthcoming, it may not be possible to determine the extent of contamination with an adequate degree of confidence. Secondary objectives include ascertaining the relationship between measurements and building cleaning history and ascertaining the role of HVACs in the potential recirculation of WTC dust. Based on evaluation of the results, a second phase of sampling may then extend into other areas.

The intent is to characterize entire buildings by sampling a number of units within each building selected. The area of sampling extends throughout lower Manhattan to Houston Street, an area roughly double the size of the area included in the initial dust cleanup program. The “target population” of buildings includes all “public” and “private” buildings that volunteer to participate. Public buildings are defined as buildings which are occupied by public institutions, such as schools, firehouses, public housing, and buildings housing government offices. Private buildings include apartment buildings and private office/commercial buildings. For purposes of the objectives stated above, these public and private buildings can also be characterized with regard to potential exposures – whether they are residential or non-residential, and non-residential mostly denotes buildings that house commercial or workplace environments. Some buildings may have both residential and non-residential spaces. A list of buildings will be compiled including all buildings that volunteer to participate in the survey. Complete participation in this survey is required, meaning that a sufficient number of units within these buildings must be made available for sampling. Only with this level of participation can the survey be characterized as a “building survey” (in contrast to an apartment survey, an office survey, or a different survey with a smaller sampling unit). As discussed below, a procedure to sample numerous “units” within the building will allow for an adequate building characterization.

**B. Sampling Design:** A statistical approach referred to as spatially balanced sampling will be used to select a sample of buildings from the list of all eligible buildings. Spatially balanced sampling was developed as a powerful and flexible technique for selecting spatially well distributed probability samples with wide application to sampling of environmental populations. The methodology is described in Stevens, D. L., Jr. and A. R. Olsen (2004). “Spatially-balanced sampling of natural resources.” *Journal of American Statistical Association* 99(465): 262-278. The spatially balanced sampling methodology has been applied successfully to the sampling of lakes, rivers and streams and other environmental sampling applications in which selection of a probability sample that provides balanced coverage over a specified geographic area is required.

The buildings to be sampled in lower Manhattan constitute a finite population of distinct units that occupy fixed locations specified by two-dimensional coordinates. The geographic coordinates for each building are the key to the sample selection process. The building coordinates are transformed mathematically to create an ordered spatial address for each building which then becomes the basis for selecting buildings to be sampled via the spatially balanced random selection procedure.

The sample design can be adjusted to accommodate a variety of sampling objectives and requirements. For example, categories of distance from the WTC site can be used to stratify the population and sampling can be designed to have equal numbers of buildings per category or proportional sampling by category. Different categories of buildings are possible such as building type, cleaning status or HVAC category. If stratifying based on building characteristics other than distance from Ground Zero is possible, then it may be implemented. However, the main objective of the current sampling program is to support estimates of geographic extent.

In order to implement a spatially balanced sample selection for the lower Manhattan area, the following must be accomplished:

(1) Identify the geographic area for sampling: Figure 1 shows the location of key areas where an analysis by EPA's Environmental Photographic Interpretation Center (EPIC, 2004) determined the extent of deposition of WTC dust and debris. The ground dust/debris boundaries in Figure 1 were derived from the analysis of multiple images taken between September 11 and September 13, 2001. This is the area that EPA believes was most heavily impacted by the dust generated when the towers collapsed. As can be seen in Figure 1, "confirmed dust/debris" areas extend to approximately Chambers Street, "probable dust/debris" areas extend to approximately Canal Street, and "possible dust/debris" areas extend to approximately Spring Street on the West side near the Holland Tunnel. Figure 2 displays this area in lower Manhattan on a color-coded map, and based on this analysis and public input, EPA has designated the area beneath Houston Street to be included in the sampling. Houston Street is shown in Figure 2 as a dashed line.

(2) Identify buildings eligible for sampling: Efforts are underway to develop a list of eligible buildings. EPA is working with public agencies at the federal, state and local level to identify public buildings which will allow EPA access for sampling. Concurrently, EPA and the WTC Panel's Community Participation Committee have begun a Community-Based Participatory Research effort to provide a formal mechanism for community input into the planning and design of project protocols and research and to help enlist participants for this building survey. These efforts will result in a list of residential and non-residential buildings which will be eligible to be selected for the survey.

An important qualifier to this list of buildings is that there will be a building self-selection bias built into this survey. A "self-selection bias" is defined as the bias introduced because the survey participants will volunteer, rather than be randomly selected from all possible survey participants. Self-selection could result in a non-representative sampling. It is expected that the efforts to enlist public and private buildings will be successful and that the list of eligible buildings will include a cross section of building types, and there will be a sufficient geographic spread of buildings.

Once this list is complete, building selection can proceed. There may be a desire to enter a second stratum variable to the survey at this point (i.e., building type). For example, there may be a desire to guarantee a sufficient size of apartment buildings in a survey. If so, then building

selection would consider not only spatial coverage, but a concurrent desire to guarantee a sufficient sample size of specific building types. This option can be considered once the list of eligible buildings is complete.

(3) Construct the spatially balanced sampling frame: The sampling frame (i.e., the list of buildings from which the sample is to be drawn) will be comprised of the buildings that volunteer to participate. The buildings will be located within the area to be sampled by their coordinates and stratified by distance from the WTC site. The number of distance categories and number of samples per category will be determined once the final list of eligible buildings is determined. The spatially balanced sampling methodology will be used to select the sample as described by Stevens and Olsen (2004).

Alternative stratifications of the sample population will be explored in the process of constructing a sample. For example, Figure 2 shows the lower Manhattan area bounded by Houston Street with regard to the EPIC results with confirmed dust/debris areas in red; probable dust/debris areas in orange and possible dust/debris areas in pink. These area designations could be combined with distance categories to create an effective stratification of the population. The distance stratification can be constructed to form what are, in effect, concentric circles around the WTC site while the dust/debris categories would insure that sufficient sample coverage in these areas is obtained. Figure 3 displays a possible outcome of applying this spatially balanced approach using distance categories as suggested. The squares and crosses in the figure are hypothetical buildings situated around Ground Zero at varying distances. The squares are buildings that might comprise the final set of buildings to sample, and the crosses identify other eligible buildings that were not selected. The black square/crosses are the nearest category at 0 to 500 meters from Ground Zero, while the green are the furthest category at 1500 to 3000 meters. It is seen from this figure that good geographic coverage in lower Manhattan in all directions is achieved. Other possible stratification factors such as building type can also be explored but all of these considerations are highly dependent on the number and location of volunteer buildings.

**C. Approach to Building Characterization:** In order to gain sufficient coverage of each building, an appropriate number of units will be sampled based on the number of floors or other building characteristics. Therefore, taller buildings or buildings with a large footprint may receive more representation in the results in terms of numbers of samples. Adjustments may be required to account for location so that buildings with more data do not misrepresent spatial patterns. A “unit” generally denotes a reasonably small, confined and well defined area that will be different for each building and building type. For example, a unit within a school could be a classroom, within a residential building could be an apartment, and within an office building could be an area including several cubicles and private offices. Priority in unit selection will be given to the units closest to Ground Zero (i.e., the ones most nearly facing Ground Zero) and to units served by HVAC systems. Two sets of dust samples will be taken within each unit: 1) locations where dust-related exposures are likely to occur, such as in elevated horizontal surfaces (e.g., desk or table tops) and floors, and 2) locations where WTC dust may have

accumulated but not necessarily been cleaned, such as behind or on top of cabinets. As described below, dust samples will be used to determine whether or not a cleaning will be offered to the occupant or owner of the unit and building being tested. These latter samples taken from inaccessible areas will not be used for this cleanup decision-making, but rather will be used only to determine the geographic extent of WTC impacts. Wipe samples as well as HEPA vacuum samples will be taken. Wipe samples will be taken from non-porous surfaces such as table tops, and HEPA samples will be taken on porous surfaces such as rugs or fabric furniture. Enough sample volume will be taken so that contaminant analysis can measure for what are anticipated to be WTC signature contaminants, as well as other contaminants of potential concern (COPCs; see overview below).

**D. Contaminants of Potential Concern (COPCs):** COPCs measured in this program include asbestos, silica, man-made vitreous fibers (MMVF), polycyclic aromatic hydrocarbons (PAHs), and lead. A full discussion of these COPCs can be found in *World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks* (EPA, 2003a). This document includes justifications for selecting these WTC-related contaminants as COPCs, and also the basis for the health-based benchmarks for these contaminants in air and dust. This document, and particularly the COPC benchmarks developed in it, has been peer reviewed. Since only dust will be measured in this program, of particular note is the establishment of health risk-based benchmark for dust for two of the COPCs, PAHs and lead. These benchmark values, at 150  $\mu\text{g}/\text{m}^2$  for PAHs and 25  $\mu\text{g}/\text{ft}^2$  for lead, will be used in post-sampling decision making regarding cleanup activities (see section below on Decision Criteria). Health-based benchmark values for the other COPCs were established for sampling in air but not for dust.

Because asbestos is primarily an inhalation toxicant, a risk-based benchmark for settled dust would need to be well-correlated to an indoor air concentration. The relationship between asbestos in settled dust and indoor air is influenced by many factors (e.g., activity patterns, surface texture, room volume, air-exchange rates, fiber dimension) and is, consequently, highly variable. Thus, the development of a risk-based benchmark for asbestos in settled dust would have a high uncertainty factor. Although it is also a contact irritant, MMVF, like asbestos, is mainly an inhalation toxicant. Therefore, an MMVF risk-based benchmark for settled dust also needs to be well-correlated to an indoor air concentration. Finally, and also like asbestos and MMVF, silica is primarily an inhalation toxicant. However, the benchmark for silica developed in the COPC document (EPA, 2003a) for indoor air is based on detection limits, not on health risk considerations. Therefore, a health-based benchmark for silica in settled dust, based on a relationship between settled dust and air concentrations, is not applicable. Consequently, like asbestos and MMVF, a benchmark for silica will be based on background levels in dust.

Lead (Pb), which can cause serious learning disabilities and behavioral problems in children, is commonly found in the air, water, soil and indoor dust of the urban environment, as well as in people's diets. It is often present in older housing that may contain lead-based paint. According to HUD data, about five percent of the housing stock in the Northeast has lead levels

above the  $25 \mu\text{g}/\text{ft}^2$  benchmark. In buildings constructed before 1939, more than ten percent exceed  $25 \mu\text{g}/\text{ft}^2$ . This factor makes it difficult to distinguish between lead from WTC dust and other sources, especially in older buildings. However, sampling and analyses for lead will be conducted in this sampling effort. All findings will be reported to owners and occupants, and decisions made regarding cleanup based on elevated lead findings will be as described below for all COPCs. In addition to evaluating whether the dust containing elevated lead levels was associated with the WTC collapse by using the WTC signature, efforts will be made to ascertain whether lead paint or other sources could also explain the lead exceedance of the benchmark. These efforts could include X-ray Fluorescence (XRF) analysis, examination of buildings records, and any visual observations that are made at the time of sampling such as peeling paint. All results of this corollary investigation into the causes for lead elevations will be reported to the owners and occupants of the units tested. The owners/occupants will be advised as to whether additional activities beyond the unit cleanup are warranted.

It is important to note that dioxin has also been identified as a WTC COPC, but it is not on the list. Like lead, dioxin is a ubiquitous urban contaminant, so attributing dioxin findings to WTC is difficult. However, unlike lead, dioxin dust sampling during EPA's Indoor Air Cleanup program in 2002 found very little dioxin in apartments in the cleanup zone. Of 1538 dust samples taken in 262 apartments, only 8 samples (or 0.5%) showed a level greater than the dust standard developed by EPA Region 2 of  $2 \text{ ng TEQ}/\text{m}^2$ . (TEQ is an acronym for Toxic Equivalents which is a summary measure of toxicity for dioxins.) Furthermore, dioxin levels found were not significantly different from levels in the background study. The single high outlier of  $75 \text{ ng TEQ}/\text{m}^2$  was found on a mantel over a fireplace; given that dioxins are a product of incomplete combustion, an elevated level above a fireplace is not unexpected.

The concurrent WTC signature effort (discussed below) is currently targeting various synthetic vitreous fiber types, concrete and wallboard particles, and selected PAHs as possible signature compounds to identify WTC dust and combustion by-products. Before any samples are taken, the WTC Signature Subgroup will provide information on the necessary sample volume and analytical methods which will allow for the measurement of the dust and air samples for the signature constituents with an appropriate level of detection.

**E. Analytical Methods and Sampling Protocols:** These are shown in Table 1. Lead will be sampled with wipes, as the health-based benchmark for lead is based on a wipe sampling method (EPA, 2003a). PAHs will also be sampled by wipes. The health-based benchmark for PAHs was developed based on exposure and health-impact considerations and was not specific to a sampling method (EPA, 2003a). It is expected that wipe sampling will capture the PAHs that exist on dust particles and also PAHs that could be trapped on oily films that may be present on non-porous surfaces like table or countertops. As such, a wipe sampling approach for PAH measurement is expected to provide a conservative (i.e., as high as possible) estimate of the PAHs available for exposure. The remaining COPCs (asbestos, MMVF and crystalline silica) will be sampled using a HEPA vacuum. Here, the decision to use a vacuum approach for these COPCs in contrast to a wipe method again is to conservatively capture embedded fibers in

porous surfaces (carpets and upholstered furniture) aggressively, and to get enough dust sample in order to measure for signature compounds as well as these three COPCs. A disadvantage to HEPA sampling methods is that the results for these contaminants will be concentration-based (fibers/gram for MMVF and asbestos, and g/g, or %, for crystalline silica) and not surface loading-based (fibers/cm<sup>2</sup> for MMVF and asbestos, and g/cm<sup>2</sup> for crystalline silica). Surface loadings can more easily be tied to exposures as compared to concentrations. Since the cleanup standard is tied to background and not to exposure/health risk for these three contaminants, the advantage of obtaining more dust for sampling was felt to outweigh other considerations, and HEPA vacuuming will be used for the WTC signature contaminants as well as for asbestos, MMVF and crystalline silica. Attachment 1 is a detailed description of the HEPA vacuuming method used by EPA's Emergency Response Team in Edison, New Jersey. This protocol will be amended by the use of a HEPA filter, which was used by the Agency for Toxic Substances and Disease Registry (ATSDR) in their sampling of residential apartments which occurred in November of 2001 (NYCDOHMH/ATSDR, 2002). Some of these are the methods and protocols that were used in EPA's background (EPA, 2003b) and confirmation cleaning study (EPA, 2003c).

**F. Heating, Ventilation, and Air Conditioning (HVAC) Sampling:** In order to characterize central HVAC units in buildings which have full or partial central HVAC units ("full" defined as units serving both common areas and individual apartments, offices, etc; while "partial" is defined as units serving only common areas while apartments or offices have individual units), bulk samples will be taken in: 1) outdoor air inlets to HVAC; 2) air mixing plenums serving sampled floors; and 3) HVAC outlets discharging to locations where COPC samples are taken. Additionally, HVAC filters will be sampled. While all samples may be informative with regard to WTC impact, it is expected that the last noted sample location (where the HVAC discharges to where COPC samples are taken) may be the most informative with regard to elucidating the role HVAC systems have on recirculating WTC contaminants to exposure areas.

**G. Decision Criteria for Activities That Could Occur Following Sampling:** The indoor sampling program outlined in this proposal will provide data that will be the basis for decision-making on whether to extend the area for sampling to determine the extent and magnitude of WTC dust presence. This information is also key to determining what further cleaning activities in lower Manhattan might be appropriate. This section outlines the decision process that will be used to determine whether levels of WTC contamination found during this sampling program are sufficient to merit cleanup of either the unit (commercial or residential) being sampled within a building or the whether the entire building being characterized should be offered an opportunity for cleanup.

There are two sources of information that can contribute to the decision-making process. These are the measurements of contaminants of potential concern and the "signatures" of WTC building debris dust and combustion products. At this point in time, the existence of "signatures" and validated methods for their identification has yet to be demonstrated although



early work on both of the signatures is promising. This signature validation will proceed in parallel with the sampling program for contaminants of potential concern. The criteria for “success” in validating the WTC signature has not been laid out, but certainly these components must be present: 1) it must be clearly defined - the candidates to date appear to be various synthetic vitreous fiber types for the building collapse and a particular PAH congener profile for the fire plume; 2) there must be evidence that the signature was found indoors in settings likely impacted by WTC collapse or emissions; and 3) there must be evidence that it is not at background locations distant from the WTC. The WTC Expert Technical Review Panel will be used to develop and review the WTC Signature Study.

(1) The signature study is fully successful in identifying a signature in indoor dust that can be reliably tied to the building collapse.

Where COPCs exceed benchmarks in exposure samples such as from rugs or countertops (in contrast to inaccessible area samples such as behind refrigerators or on top of bookshelves which will be taken and analyzed primarily to evaluate geographic extent), a cleanup will be offered the owner or occupants for those units or buildings sampled that have the COPCs associated with dust from the WTC. Following a cleanup, the units or buildings will be resampled for the COPCs that exceeded the benchmarks to ensure that the cleanup brought levels to below benchmarks.

Typically, EPA would base decisions on cleanup against health-based benchmarks for concentrations of COPCs. In this sampling program, the method for determining concentrations of COPCs will be by wiping hard surfaces or vacuuming porous surfaces for settled dust. This has been the preferred approach for many groups in the community affected and for many members of the Expert Panel. The amount of research necessary to establish health-based benchmark concentrations in dust for the remaining decision-making COPCs precludes pursuing their derivation if the sampling program is to proceed in a timely manner. Thus, health-based benchmarks will not be available for asbestos, MMVF, or silica. Instead, EPA will establish non health-based “cleanup benchmarks” for them. For PAHs and lead, the health-based benchmarks,  $150 \mu\text{g}/\text{m}^2$  for PAHs and  $25 \mu\text{g}/\text{ft}^2$  for lead based on wipe sampling methods, will be used as the appropriate benchmarks in this decision framework.

For the other COPCs, “cleanup benchmarks” will be established at three times background levels for the particular COPC. Precedent for this approach is found in the criteria used in screening sites for possible inclusion in the National Priority List (NPL) for Superfund. Attachment 2 shows Section 2 of the December 14, 1990 Federal Register Notice, Hazard Ranking System; Final Rule (55 FR 51532). In this section, titled “Evaluations Common to Multiple Pathways”, conditions are described where an environmental release from a site that is being evaluated for the NPL is of potential concern: “If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement is 3 times or more above the background concentration.” It should be noted, however, that this approach is only used to determine whether there is a release from a potential Superfund site;

remediation decisions in Superfund are based on health-based benchmarks. This approach does not allow comparison to health-based benchmarks.

Background values for these COPCs will be developed using various source references, including the Background Study conducted by EPA Region 2 in 2002 (EPA, 2003b), the current study of WTC impacted and background buildings being conducted as part of the signature study (see description below in Signature Study section), and the open literature. The WTC Expert Technical Review Panel will be used to review possible cleanup benchmarks and review the information generated on background levels of COPCs from the WTC Signature Study.

The following shows the current status of benchmarks for the WTC COPCs.

<b>COPC</b>	<b>Benchmark</b>	<b>Sampling Method</b>	<b>Basis for Benchmark and Other Comments</b>
Asbestos	TBD*	HEPA	3X background; HEPA vacuum-based value to be determined in current signature study background sampling
MMVF	TBD	HEPA	3X background; HEPA vacuum-based value to be determined in current signature study background sampling
Crystalline silica	TBD	HEPA	3X background; HEPA vacuum-based value to be determined in current signature study background sampling
PAHs	150 µg/m <sup>2</sup>	Wipe	Health-based as described in COPC document (EPA, 2003a)
Lead	25 µg/ft <sup>2</sup>	Wipe	Health-based, adapted from HUD standard which specifies wipe sampling methods, as described in EPA, 2003a.

\* To be determined

Figure 4 displays a decision tree for this evaluation. It is assumed that the signature validation study is completed and has been successful in identifying either, or both, the building collapse and the fire plume signatures.

It is observed in this decision tree that the proposed decision criterion for a judgment relating to full building cleanup involves the use of a 95% Upper Confidence Limit (UCL) standard on a mean contaminant level. An Upper Confidence Limit (UCL) is a measure of uncertainty in an estimated mean due to sampling, measurement and other sources of variability in a set of data. The 95% UCL defines a value that will be greater than or equal to the true mean approximately 95% of the time in repeated sampling. The 95% UCL is commonly employed in

EPA hazardous site assessments to provide a conservative upper bound estimate on the average site-wide contaminant level. The UCL will be used in the decision process as follows: If the 95% UCL for the estimated building mean exceeds the benchmark value for a COPC, and concurrently, there is evidence of the WTC signature in the sampled dust in the building, then this may be considered to provide support for the decision to clean the building. It should be noted that if lead triggers the 95% UCL criteria as described here, a building cleanup will occur as with other COPCs triggering the 95% UCL. However, if it is found that the lead elevations are attributable to lead-based paint, a lead paint abatement effort will not occur.

Decisions will also need to be made once the sampling is completed relating to expansion into a Phase II program that extends beyond the borders of the current sampling effort, and also whether the data supports a more general cleanup program anywhere in the sampling area. Although the criteria have yet to be established regarding these two critical post-survey decisions, clearly the general model used for unit and building cleanup will also be employed. Specifically, decisions regarding expansion into a Phase II will be based on an examination of the data for the buildings in the sampled areas furthest from Ground Zero, and expansion would be justified if there is ample evidence of both the presence of the WTC signature as well as exceedance of the COPC benchmarks. Similarly, decisions as to whether a new general cleanup program is warranted anywhere in the sampled area will be based on a careful examination of the data with particular attention to the spatial distribution of the WTC signature and exceedances. Final decisions on these post-survey activities will be made by EPA in consultation with the WTC Expert Technical Review Panel and the Community-Based Participatory Research planning group.

(2) If the signatures are not identified or their use proves unreliable, the decision for sample unit cleanup will have to rely on the levels of contaminants of potential concern alone.

The absence of a WTC signature may make it very difficult to determine the geographic extent to which WTC dust has impacted indoor environments and whether any exceedances of COPCs are related to the WTC collapse. In the absence of a measure that can identify WTC dust, the WTC Expert Technical Review Panel and the Community-Based Participatory Research planning group will be asked to evaluate the overall results of the sampling program and provide EPA with their interpretation of the results. These interpretations will be used by EPA, along with previously collected ambient monitoring data, modeling results, and EPA's own analysis of the sampling results, to make recommendations about sampling unit cleanups, expansion of the sampling areas, or more general cleanup activities.

## **II. WTC SIGNATURE VALIDATION STUDY**

The purpose of this study is to develop and validate one or more "signatures" in indoor dust that can be used to determine whether dust sampled as part of EPA's planned sampling program can be attributed to collapse of the WTC towers or is of a different origin. A

“signature” is a chemical or physical characteristic of a material that can be used to identify that specific material and discriminate between the material sought (WTC dust, in this case) and other similar materials (New York City urban dusts). The specific methods or chemicals used to decide the dust’s origin are not necessarily related to health concerns. The signature could be something totally innocuous but unique to the WTC source, measured only to identify the origin of other chemicals of concern that occur in the same sample.

The collapse of the WTC towers produced many tons of airborne dust, and this dust spread over a wide area of lower Manhattan and beyond. The fires from the WTC site burned for many weeks after the collapse, and emissions from these fires were carried by the wind to areas across New York City and perhaps beyond. Although some buildings were cleaned through an earlier effort by EPA and others, there are health-related concerns about WTC dust that may still remain inside buildings in the NYC area. The WTC signatures, if they can be developed, will support analysis to discriminate between normal indoor dusts and WTC-generated dusts, to aid in identifying the areas for cleanup.

Because of the different materials in the dust cloud from the initial collapse of the buildings and the smoke plume generated by the subsequent fires, two different types of signatures - building collapse and WTC smoke - will be sought for these two different types of airborne particles. In both cases, for the building collapse and for the fires, the signatures need to be: 1) unique to WTC dusts (distinct from urban dusts); 2) persistent for many months (not volatile); 3) homogeneous in WTC dust (evenly distributed through samples of WTC dust); 4) able to be detected with small sample size, low minimum detection limit, and low interference from other dust components; and 5) consistently found in impacted areas. To facilitate the analysis of the hundreds of samples from areas across the greater NYC area, the analysis methods for these signatures should preferably also be low cost, available through commercial laboratories, relatively rapid, and should employ automated assay methods.

The dust cloud from the building collapse contained a mixture of finely pulverized building materials. Scientists at the United States Geological Survey (USGS) Laboratories in Denver, Colorado are using electron microscopy and chemical analysis methods (SEM-EDS) to identify and characterize hundreds of individual particles in samples collected soon after September 11. Although the major, minor and trace components of WTC dust are well documented, these components have not been systematically evaluated for the purpose of identifying trace levels of WTC contamination in indoor dust. A variety of samples of bulk dust will be analyzed to estimate relative concentration levels of as many key components as possible. These analyses will use point counting methods developed at the USGS for EPA Region 8. Results will be tabulated according to sample location. Factors such as distance from source and elevation will be evaluated. COPCs will also be analyzed to determine the quantitative relationships between signature components and COPCs.

In addition to the analysis of bulk WTC dust, background samples will be analyzed to verify that signature components are not present at levels that would compromise the use of the

signatures in identifying WTC dusts. Background samples are critical to any analysis program, including this study and any new sample collection and analysis program for COPCs. The only way to demonstrate that contamination is from the WTC is to show the absence of key components (alone or in combination) in background.

From preliminary work, the materials that might be used as a signature include a variety of synthetic vitreous fiber types (slag wool, mineral wool, and soda-lime glass) possibly in combination with concrete and/or gypsum. This careful microscopic analysis will set the framework for selecting a chemical and/or particle shape-related (e.g., fiber shape) signature and for the possible subsequent development of automated analysis methods for a building collapse signature.

Scientists at Rutgers University, EPA's Office of Research and Development, and the University of North Carolina are working to develop fire emissions signatures. Signatures proposed for the fires include:

A. Pattern of organic chemicals in dust particles: The WTC fires produced a complex mixture of organic chemical emissions. Analysis of fine particle samples from several contaminated and uncontaminated sites show a pattern of different organic components that might be developed as a signature for the fires.

B. Ratio of specific polycyclic aromatic hydrocarbons (PAHs): PAH compounds, carbon-containing chemicals with more than one benzene ring in each molecule, are formed when carbon-containing materials are burned. Some of these PAH compounds appear to be found at greater concentrations in WTC dusts, as compared to dusts from areas outside the fire plumes. A trace analysis method is being developed, focusing on the ratios of selected PAHs.

A program to acquire indoor dust samples to assist in the development and evaluation of WTC dust signature is underway. The first set of samples has been obtained from a contaminated building next to the WTC site. Dispersion models, photos, interviews and satellite data will be reviewed to discern areas that were probably impacted by WTC emissions. Samples from 20 buildings will be collected for validation of the proposed signatures. Samples will be collected from 10 buildings in the area that is suspected to be affected by WTC emissions, and samples will be obtained from 10 buildings that are not suspected of being affected. In each building identified for sampling, dust samples will be collected from at least three areas: 1) one sample from a track-in area near a building entrance, preferably in a carpeted area; 2) two samples from relatively undisturbed areas (e.g., on top of bookcases, under furniture); and 3) other areas showing visible accumulation of settled dust, including HVAC ducts. A standard method using a HEPA vacuum collector will be used by EPA to collect bulk dust samples. Samples will be sealed and stored under refrigeration in a limited access area.

To ensure that these important samples are properly collected, tracked, stored, and distributed, comprehensive quality assurance (QA) procedures will be in place prior to any

sample collection. There will be a survey of building and sampling areas, to include photos of sampling areas (if permitted by building owners) and notes on building usage, to identify conditions that might compromise samples (e.g., smoking or cooking areas).

Samples will be analyzed for the proposed signatures and for the contaminants of potential concern (COPCs) as identified by the WTC Expert Panel. The results of these analyses will be made available as soon as possible after EPA has reviewed the data for QA. The sampling for background dust and WTC dust is targeted for completion by the middle of November 2004. This could be delayed if obtaining access to appropriate sampling locations becomes an issue. EPA will proceed with signature development and analysis as rapidly as possible and will release these results to the WTC Expert Panel and the public for use in the larger sampling plan as soon as possible.

## REFERENCES

EPIC, 2004. Mapping the Spatial Extent of Ground Dust and Debris from the Collapse of the World Trade Center Buildings. Jennings, D.G., D. J. Williams, and D. Garofalo, authors. Environmental Photographic Interpretation Center, Landscape Ecology Branch, Environmental Sciences Division, National Exposure Research Laboratory, Office of Research and Development, US EPA. Reston, VA 20192. DRAFT February 2004.

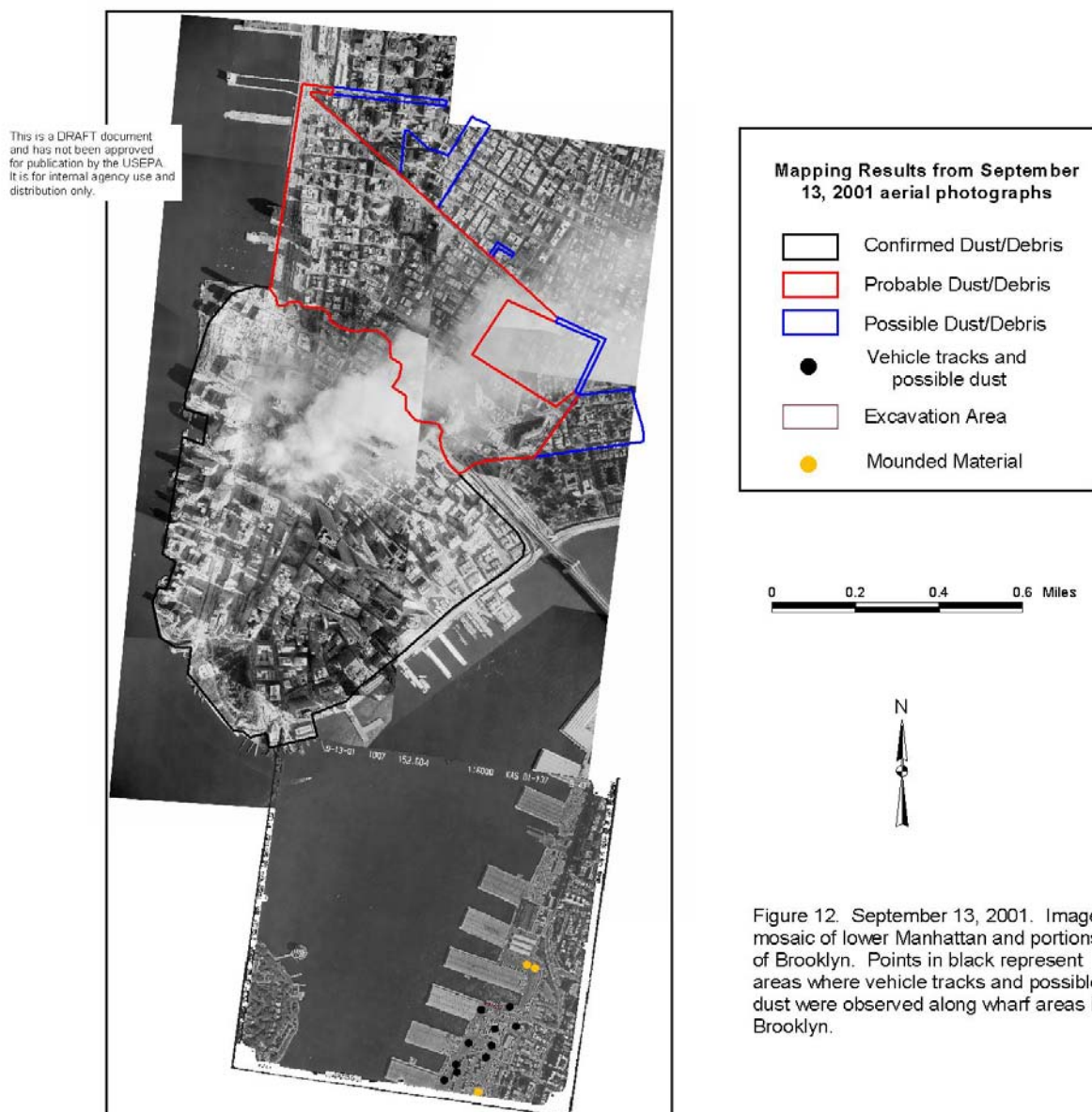
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Stevens, D. L., Jr. and A. R. Olsen (2004). Spatially-balanced sampling of natural resources. *Journal of American Statistical Association* 99(465): 262-278.

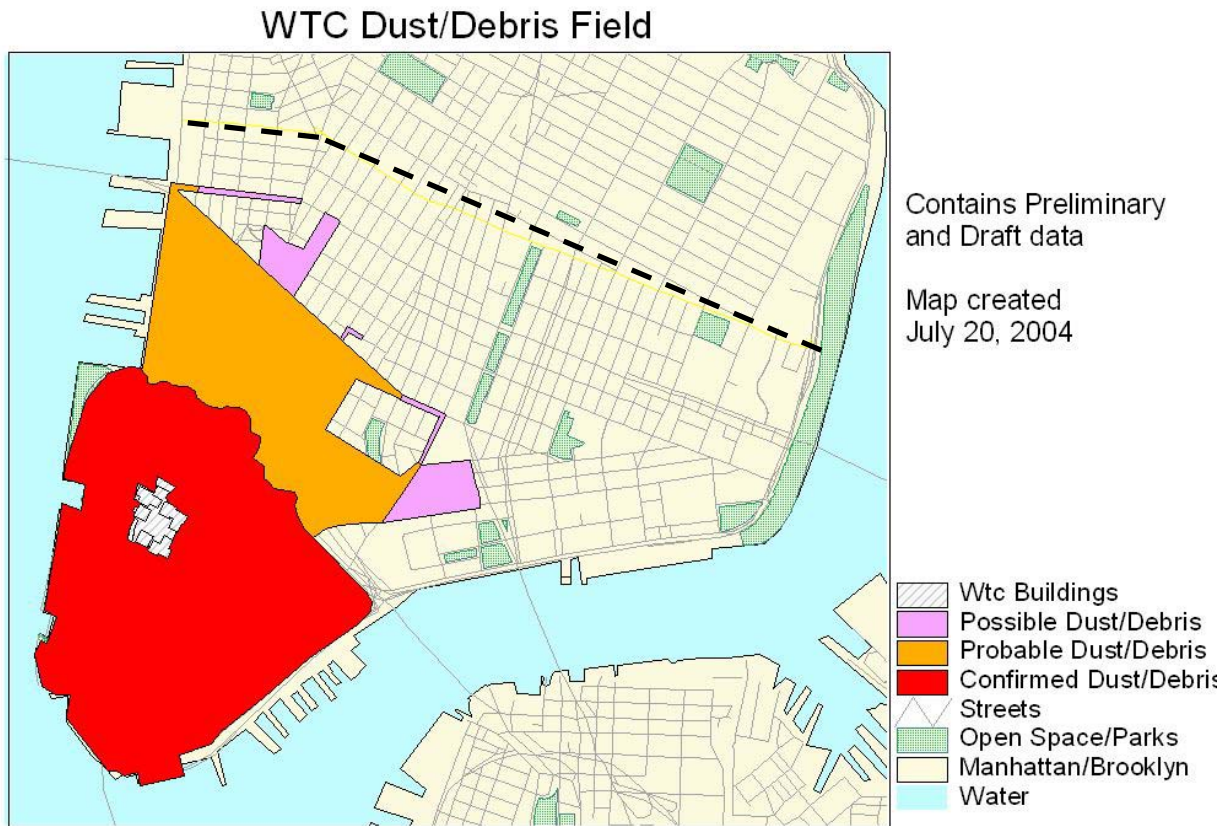
US EPA. 2003a. World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks. Prepared by the Contaminants of Potential Concern Committee of the World Trade Center Indoor Air Task Force Working Group. May, 2003.

US EPA. 2003b. World Trade Center Background Study Report. Interim Final. Prepared by US EPA Region 2, New York Response and Recovery Operations. April, 2003

US EPA. 2003c. Residential Confirmation Cleaning Study. Interim Final. Prepared by US EPA Region 2, New York Response and Recovery Operations. May, 2003.

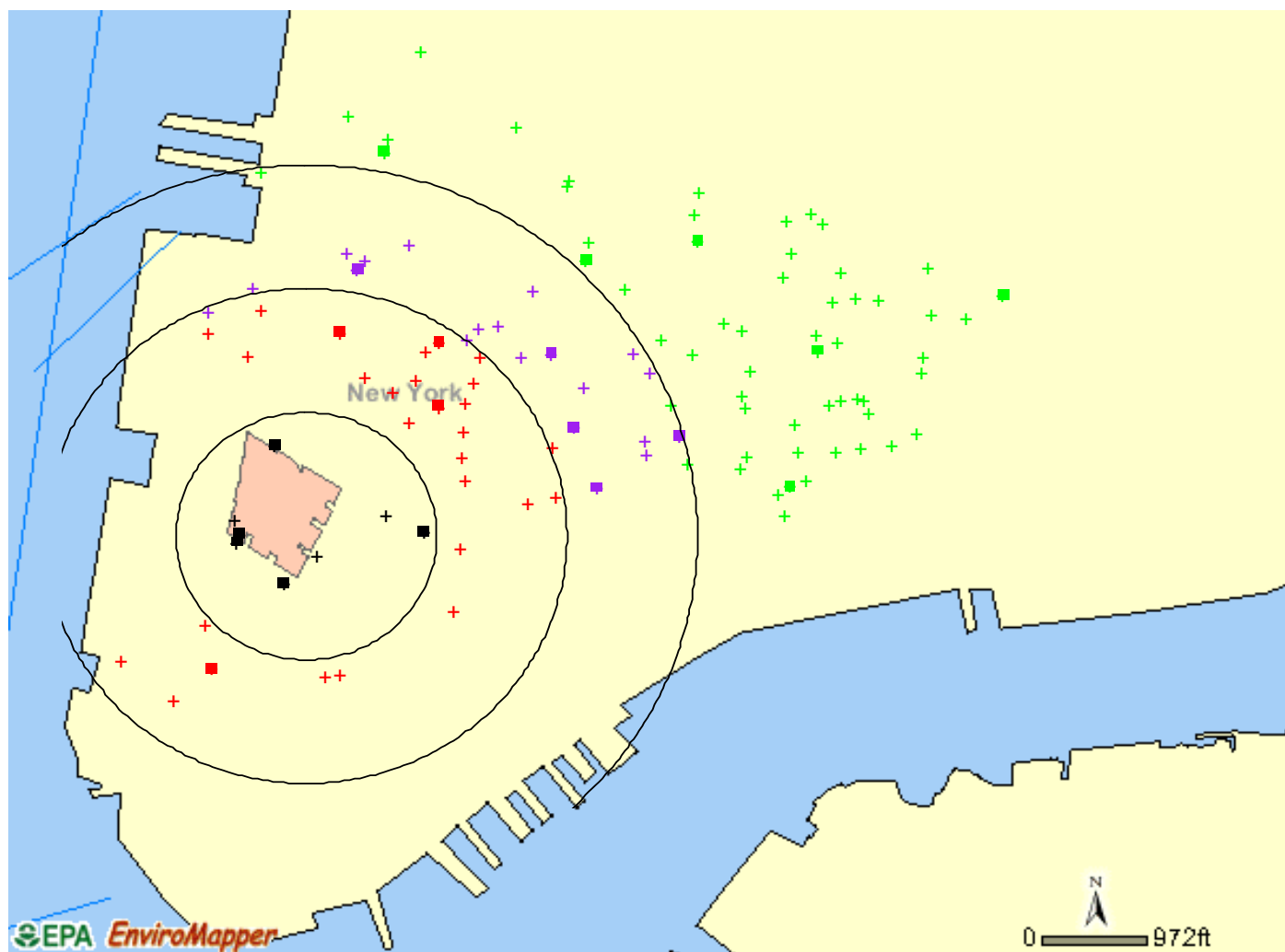


**Figure 1.** Display of boundaries of expected deposition based on analysis conducted by EPA's Environmental Photographic Interpretation Center (EPIC, 2004).



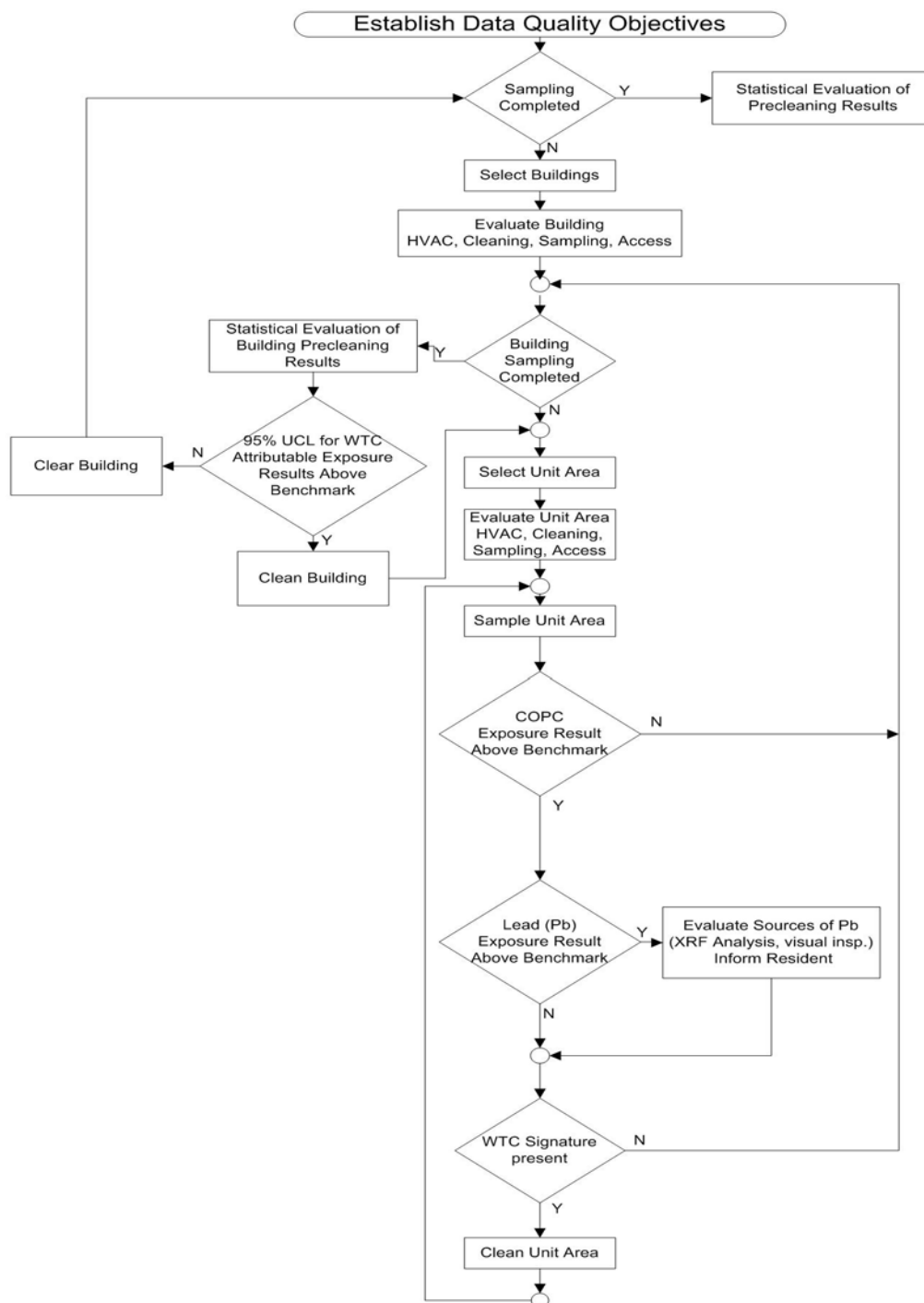
**Figure 2.** The study area of lower Manhattan bounded by Houston Street, shown in dashed lines, overlain on the EPIC results which are displayed in three colors: red meaning confirmed dust/debris; orange meaning probably dust/debris, and pink meaning possible dust/debris.





Key: Squares: buildings actually selected; Crosses – buildings that are eligible to be selected. Black – buildings within 0 to 500 meters of Ground Zero; Red – buildings 500 to 1000 meters; Purple – buildings 1000 to 1500 meters; and Green – buildings 1500 to 3000 meters.

**Figure 3.** Example of possible outcome of a spatially balanced approach to building selection (see text for a further description of this map).



**Figure 4.** Decision tree to determine whether an offer will be made to clean a tested unit, as

well as the building as a whole.

**Table 1. Proposed Sampling and Analytical Methods for the Building Sampling Program.**

<i>Media</i>	<i>Sampling Points</i>	<i>Analytical Parameters</i>	<i>Sampling Method Proposed</i>	<i>Description</i>	<i>Analytical Method Proposed</i>	<i>Proposed Reporting Limits</i>
Settled Dust Porous Soft Surfaces	Carpets, fabric furniture or drapery in areas of activity (living rooms, class rooms, offices, etc.) and accumulation (behind or on top of cabinets/bookcases).	Asbestos	ERT Method (see Attachment 1)	HEPA vacuuming method.	TBD	TBD
		Silica	ERT Method (see Attachment 1)	HEPA vacuuming method.	TBD	TBD
		MMVF	ERT Method (see Attachment 1)	HEPA vacuuming method.	TBD	TBD
Settled Dust Non-porous Hard Surfaces	Horizontal surfaces of tables or counters and bare floors, ceilings and walls in areas of activity (living rooms, class rooms, offices, etc.) and accumulation (behind or on top of cabinets/bookcases).	Lead	HUD Appendix 13.1	Wipe Samples.	SW-846 6010B	2 ug/ft <sup>2</sup>
		PAHs	ASTM D 6661-01	Wipe Samples.	ASTM 6661-01/SW-846 8270C	0.150 mg/m <sup>2</sup>
HVAC Systems	HVAC Systems -Inlet and outlet	Asbestos	ASTM D 6480-99	Wipe Samples.	ASTM D 6480-99 (wipe)	1000 structures/cc
		Lead	HUD Appendix 13.1	Wipe Samples.	SW-846 6010B	2 ug/ft <sup>2</sup>
		PAHs	ASTM D 6661-01	Wipe Samples.	ASTM 6661-01/SW-846 8270C	0.150 mg/m <sup>2</sup>
		Silica	HUD Appendix 13.1**	Wipe Samples.	NIOSH 7500 (XRD)	1000 ug/ft <sup>2</sup>
		MMVF	ASTM D 6480-99	Wipe Samples.	EMSL MSD.0300 or Equivalent	1000 f/cm2

**Table 1 (continued).**

<i>Media</i>	<i>Sampling Points</i>	<i>Analytical Parameters</i>	<i>Sampling Method Proposed</i>	<i>Description</i>	<i>Analytical Method Proposed</i>	<i>Proposed Reporting Limits</i>
HVAC Filters	HVAC, AC, or HEPA unit filters (collection of bulk dust sample from air filters and mixing plenums).	Asbestos	Bulk Sample	Bulk Samples.	PLM NYS 198.1 followed by TEM NYS 198.4	1000 structures/cc
		Lead	Bulk Sample	Bulk Samples.	SW-846 6010B	2 ug/ft <sup>2</sup>
		PAHs	Bulk Sample	Bulk Samples.	SW-846 8270	<0.3 mg/m <sup>2</sup>
		Silica	Bulk Sample	Bulk Samples.	NIOSH 7500 (XRD)	1000 ug/ft <sup>2</sup>
		MMVF	Bulk Sample	Bulk Samples.	PLM NYS 198.1/EMSL MSD.0300 or Equivalent	1000 f/cm <sup>2</sup>

ATTACHMENT 1. HEPA Vacuuming Method Used by EPA's Emergency Response Team

Collection of Indoor Dust Samples from Carpeted Surfaces for Chemical Analysis  
Using a Nilfisk GS-80 Vacuum Cleaner

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## 1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to define the procedures for collection of carpet-embedded dust samples that can then be analyzed for lead, pesticides, or other chemical compounds and elements. This procedure is applicable for the collection of samples on a variety of surfaces.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

## 2.0 METHOD SUMMARY

Sample collection is performed utilizing the Nilfisk GS-80 vacuum cleaner equipped with a high efficiency particulate air (HEPA) filter. A diagram of the Nilfisk GS-80 vacuum cleaner is presented in Figure 1. Soil and other particulate matter with aerodynamic diameters of approximately 5-micrometers ( $\mu\text{m}$ ) and larger, that are embedded within the carpet, are collected and returned to the laboratory for sieving and analysis.

## 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

Following collection of the sample into a dedicated collection bag, the bag is removed from the vacuum cleaner and placed into a 32-ounce glass jar or a zip-lock plastic bag. Storage of the samples at ambient temperature is appropriate for samples that will be analyzed only for metals.

Note: Samples for organic analysis should be maintained at approximately 40C.

## 4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are no known interferences with this method.

## 5.0 EQUIPMENT/APPARATUS

### 5.1 Equipment List

- Nilfisk Model GS-80 vacuum cleaner
- Two meter folding ruler or similar device
- Masking tape

- Clean aluminum foil
- Shaker sieve, as specified in ASTM D4222, with 100-mesh screen
- Analytical balance [sensitive to a minimum 0.1 milligram (mg) and weighing range of 0.1mg - 1000 grams(g)].
- Distilled water
- Methanol
- Kimwipes TM or other laboratory tissue
- Vacuum collection bags
- Bottle brush
- Scrub brush
- Polyliners
- 32-ounce glass jars

## 6.0 REAGENTS

Methanol and distilled water are required for sampling train cleaning and decontamination.

## 7.0 PROCEDURES

### 7.1 Preparation

The overall sampling strategy should be designed to address the goals of the study. Users should consider factors such as foot traffic volume, types of activities, and proximity to potential sources. The sampling strategy should be described in the Quality Assurance Work Plan (QAWP) prepared prior to the sampling event. The ideal sampling locations are those areas that conform to the overall sampling strategy. For example, protocol may require the selection of a carpeted area for sampling where small children play or are likely to play.

1. Determine the extent of the sampling effort, the sampling methods to be employed, the amount of dust needed to reach the desired detection limit and the types and amounts of equipment and supplies needed.
2. Obtain and organize the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, as specified in Section 7.5, and ensure that it is in working order.
4. Prepare schedule and coordinate with staff, client, regulatory agency, as appropriate.
5. Perform a general site survey prior to site entry in accordance with the



site-specific Health and Safety Plan.

6. Measure the area to be sampled and outline it using masking tape or other appropriate methods. Draw a diagram of the room(s) where the sample(s) were taken, locating the sampled area(s).

## 7.2 Calibration Procedures

The Nilfisk GS-80 vacuum cleaner has no flow devices that need calibration prior to sampling. The sampling train shall be thoroughly inspected to ensure that it has been cleaned, properly assembled, and complete.

## 7.3 Field Operations

1. Prior to sample collection at the location to be sampled, complete a sample data sheet, recording all requested information and sketch the area to be sampled. A sample data sheet is provided in Figure 2.

2. Select a sampling area according to the established protocol defined in the QAWP. In most cases, three rooms per floor are selected for sampling in each building. Each sample is collected with a dedicated sampling train that has been properly assembled, cleaned, and decontaminated to ensure sample integrity. The size/weight of each sample is dependent on the goals and objectives of the sampling event, the analyses requested, and the desired method detection levels (MDLs). A 100-gram sample is highly desirable if multiple analyses (metals, pesticides, etc.) are requested. A minimum 5-10-gram sample is required for metal analysis.

3. Utilizing the 2-meter folding ruler or any other measuring device, outline and mark the recommended 1-m<sup>2</sup> portion of the carpet to be sampled.

4. Begin the sample collection at one corner of the delineated sample area, moving the sampler back and forth four times over a strip running in a straight line between the defined sampling area edges. The width of the strip is defined by the width of the sampling nozzle. After completing the first strip, angle over to the second strip gradually on the next pass, again completing four double passes.

5. Continue sampling the area delineated until an adequate sample is collected. To determine if adequate sample weight will be collected, one must use visual judgment or perform the finger judgment test on the carpet to judge the dust loading of the carpet and make a decision on whether to sample the recommended 1-m<sup>2</sup> area or a larger area. If sampling a larger area, measure the area accurately and document.

6. Wearing surgical gloves make sure to tap with your hand on the nozzle inlet to dislodge any dust remaining in the nozzle or the hose. This procedure will ensure

complete sample recovery. Turn off the vacuum cleaner and allow to sit undisturbed for at least 30 seconds. Unsnap the two vacuum container clips to access the inside of the container. Remove the polyliner and the vacuum collection bag within it. Then seal off the polyliner with the vacuum collection bag inside, and transfer to a properly labeled 32-oz. glass jar or plastic bag. Document the sample and store for shipping to the laboratory.

#### 7.4 Laboratory Operations

Upon arrival at the laboratory, recovery of the dust samples from the GS-80 dedicated collection bags is accomplished by the following procedure:

1. Select a clean working area in the laboratory where recovery of the samples is to be performed (a 4-foot by 4-foot area will be sufficient). Make sure that the following equipment/apparatus is available, assembled, and in good working condition:

-Shaker sieve (No. 100), as specified in ASTM D-422 with particle size separation of 150  $\mu\text{m}$ . complete set consists of three components: the cover, the screen, and the receiver pan. The receiver pan must be pre-weighed and its weight recorded.

-Sieve shaker for mechanical sieving. Models readily available are CSC Scientific Company, Inc. Catalog No. 18480 and Thomas Scientific Catalog No. 8324-A10 (Tel 800 345-2100).

-Analytical balance sensitive to a minimum 0.1 milligrams (mg) and weighing range of 0.1 mg to 1000 grams (g).

-Surgical gloves. Thomas Scientific Catalog No. 5761-W14.

-Disposable dust mask. Thomas Scientific Catalog No. 8055-M20.

-Camel's Hair Brush. Fisher Scientific Catalog No. 03-655.

-Clean aluminum foil.

-Kimwipes™ or other laboratory tissue.

2. Wearing clean surgical gloves to handle the bags and a dust mask for dust protection, retrieve the vacuum collection bags from the 32-ounce glass jars used to transport the bags from the field to the laboratory.

3. Empty the contents of the bag into the No. 100-mesh sieve screen through the bag opening. Complete this operation by removing the plastic adaptor from the collection

bag inlet. Shake the bag as necessary to ensure all the contents have been transferred through the screen to the receiver pan.

4. Place the cover on the sieve screen and manually or mechanically shake the sieve for a minimum of 5 minutes and a maximum of 10 minutes until all the fine dust particles are collected in the bottom receiver pan. If manual shaking is performed, the directions in D-422 of ASTM must be followed: "Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. Continue sieving until not more than 1 mass percent of the residue on a sieve passes that sieve during 1 minute of sieving".

If mechanical shaking is performed, set up the recommended sieve shaker on an even and stable surface. Proceed with the sieving operation following directions in the manufacturer's manual.

5. Re-weigh the receiving pan utilizing the analytical balance. The difference in weight is the weight of the sieved sample. If total weight of material is desired, the coarse material remaining on top of the sieve must be collected on a pre-weighed sheet of aluminum foil, re-weighed and the weight added to the weight of the sieved sample.

6. Transfer the sieved sample from the receiving pan to an 8-ounce wide mouth glass jar. Use the camel's hair brush to ensure complete transfer of the sample. Cap glass jar and secure sample.

7. Document each sample. Each sample must be provided with the following information: identification number, date of sampling, location, analysis requested. Each sample must be recorded into a chain-of-custody form before delivery to the analytical laboratory.

8. Before processing the next sample, thoroughly wipe clean the shaker sieve set with a Kimwipe™. Wait until dry. Repeat steps 1 through 7.

## 7.5 Sampling Train Decontamination

To decontaminate the sampling trains, move them to a well ventilated area and perform the following:

1. Assemble one of the sampling trains to be used as the decontamination unit for decontaminating the nozzles, hoses, and wands. This unit must be provided with a clean polyliner and dust bag.

2. With the vacuum cleaner turned on and wearing clean surgical gloves, the nozzles, wands, and hoses are decontaminated using the bottle brush to remove any accumulated dust in the hose and nozzle. Make sure to tap with your hand on the nozzle to

remove any visible dirt that have accumulated and use the scrub brush to remove any hair or fibers entangled on the nozzle's brush. When the nozzle is considered to be clean, remove and spray with reagent grade methanol and allow to air dry on a clean surface. The wand and hose are then cleaned with the bottle brush. Make sure to tap with your hand on the wand inlet while cleaning with the bottle brush to remove any visible dirt. Repeat this procedure to decontaminate the other nozzles, wands, and hoses.

3. Pull out the dirty dust bag from the decontamination unit and wipe clean the inside of the container with distilled water. Do the same to the other containers. Spray the inside of the containers with methanol and allow to air dry. If decontaminating in between homes, wipe cleaning the inside of the containers with distilled water is sufficient.

## 8.0 CALCULATIONS

The dust weight calculations for the final sieved dust fraction are performed in accordance with ASTM Method D 422. Dividing the final dust weight by the area sampled (expressed in m<sup>2</sup>) provides dust loading in grams per squared meter ( g/m<sup>2</sup> ). When the analysis results are received, the loading of analyte per square meter of carpet area (ug/m<sup>2</sup>) can be calculated in the same way. Analysis will also provide mg/kg concentration. If total (gross) dust loading of the sampled area needs to be calculated, the total dust weight before sieving must be obtained. The total dust weight is divided by the area sampled to obtain total dust loading per square meter.

## 9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instruments must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

## 10.0 DATA VALIDATION

Results of the quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

## 11.0 HEALTH AND SAFETY

When working with potential hazardous materials, follow U.S. EPA, OSHA and

corporate health and safety procedures.

## 12.0 REFERENCES

American Society For Testing And Materials, Standard Practice for Collection of Dust from Carpeted Floor for Chemical Analysis, Designation D 5438-93, Reprinted from the Annual Book of ASTM Standards, Philadelphia, PA.

American Society For Testing And Materials, Standard Test Method for Particle Size Analysis of Soils, Designation D 422-63, Reprinted from the Annual Book of ASTM Standards, Philadelphia, PA.

Instructions for Use-Nilfisk Model GS 80, Nilfisk of America, Inc., Malvern, PA (1987).

AMENDMENT TO ERT HEPA VACUUM SAMPLING METHOD, AS DESCRIBED IN  
NYCDOHMH/ATSDR (2003):

1. Field Changes

The sampling protocol indicated that a total of 60 residential units would be tested in lower Manhattan. A total of 59 residential units were sampled.

Indoor settled surface dust was collected using EPA's Environmental Response Team Standard Operating Procedure (ERT SOP) for household dust, as stated in the sampling protocol. However, due to cost and equipment availability constraints, Omega Ultivac vacuums with high efficiency particulate air (HEPA) filters were used instead of Nilfisk™ vacuums. To avoid the need to decontaminate the vacuum hose between each sampling event, a sample collection filter (Alsock, by Midwest Filtration) was inserted into the air intake end of the vacuum hose. The Alsock has a 97% capture of particles with diameters of 1.1 microns and larger. The ERT SOP-specified vacuum bag filter has a 4- to 5-micron pore size.

Instead of one settled surface dust sample per unit, two co-located indoor settled surface samples were collected. This change was made as two different laboratory locations were involved in the analysis. The EMSL Analytical laboratory in New York City analyzed samples for fibers (using PCM, PLM, and TEM); the EMSL Analytical laboratory in Westmont, New Jersey, analyzed samples for the remaining materials and conducted the SEM analysis for fibers.

ATTACHMENT 2 – SECTION 2 OF THE DECEMBER 15, 1990 FEDERAL REGISTER NOTICE, HAZARD RANKING SYSTEM, FINAL RULE (55 FR 51532).

**Site:** Area(s) where a hazardous substance has been deposited, stored, disposed, or placed, or has otherwise come to be located. Such areas may include multiple sources and may include the area between sources.

**Slope factor (also referred to as cancer potency factor):** Estimate of the probability of response (for example, cancer) per unit intake of a substance over a lifetime. The slope factor is typically used to estimate upper-bound probability of an individual developing cancer as a result of exposure to a particular level of a human carcinogen with a weight-of-evidence classification of A, B, or C.  $[(\text{mg/kg-day})^{-1}]$  for non-radioactive substances and  $[(\text{pCi})^{-1}]$  for radioactive substances.

**Source:** Any area where a hazardous substance has been deposited, stored, disposed, or placed, plus those soils that have become contaminated from migration of a hazardous substance. Sources do not include those volumes of air, ground water, surface water, or surface water sediments that have become contaminated by migration, except: in the case of either a ground water plume with no identified source or contaminated surface water sediments with no identified source, the plume or contaminated sediments may be considered a source.

**Target distance limit:** Maximum distance over which targets for the site are evaluated. The target distance limit varies by HRS pathway.

**Uranium Mill Tailings Radiation Control Act (UMTRCA) Standards:** Standards for radionuclides established under sections 102, 104, and 108 of the Uranium Mill Tailings Radiation Control Act, as amended.

**Vapor pressure:** Pressure exerted by the vapor of a substance when it is in equilibrium with its solid or liquid form at a given temperature. For HRS purposes, use the value reported at or near 25° C. [atmosphere or torr].

**Volatilization:** Physical transfer process through which a substance undergoes a change of state from a solid or liquid to a gas.

**Water solubility:** Maximum concentration of a substance in pure water at a given temperature. For HRS purposes, use the value reported at or near 25° C. [milligrams per liter (mg/l)].

**Weight-of-evidence:** EPA classification system for characterizing the evidence supporting the designation of a substance as a human carcinogen. EPA weight-of-evidence groupings include:

- Group A: Human carcinogen—sufficient evidence of carcinogenicity in humans.
- Group B1: Probable human carcinogen—limited evidence of carcinogenicity in humans.
- Group B2: Probable human carcinogen—sufficient evidence of carcinogenicity in animals.
- Group C: Possible human carcinogen—limited evidence of carcinogenicity in animals.
- Group D: Not classifiable as to human carcinogenicity—applicable when there is no animal evidence, or when human or animal evidence is inadequate.
- Group E: Evidence of noncarcinogenicity for humans.

## 2.0 Evaluations Common to Multiple Pathways

**2.1 Overview.** The HRS site score (S) is the result of an evaluation of four pathways:

- Ground Water Migration ( $S_{gw}$ ).
- Surface Water Migration ( $S_{sw}$ ).
- Soil Exposure ( $S_s$ ).
- Air Migration ( $S_a$ ).

The ground water and air migration pathways use single threat evaluations, while the surface water migration and soil exposure pathways use multiple threat evaluations. Three threats are evaluated for the surface water migration pathway: drinking water, human food chain, and environmental. These threats are evaluated for two separate migration components—overland/flood migration and ground water to surface water migration. Two threats are evaluated for the soil exposure pathway: resident population and nearby population.

The HRS is structured to provide a parallel evaluation for each of these pathways and threats. This section focuses on these parallel evaluations, starting with the calculation of the HRS site score and the individual pathway scores.

**2.1.1 Calculation of HRS site score.** Scores are first calculated for the individual pathways as specified in sections 2 through 7 and then are combined for the site using the following root-mean-square equation to determine the overall HRS site score, which ranges from 0 to 100:

$$S = \sqrt{\frac{S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2}{4}}$$

**2.1.2 Calculation of pathway score.** Table 2-1, which is based on the air migration pathway, illustrates the basic parameters used to calculate a pathway score. As Table 2-1 shows, each pathway (or threat) score is the product of three "factor categories": likelihood of release, waste characteristics, and targets. (The soil exposure pathway uses likelihood of exposure rather than likelihood of release.) Each of the three factor categories contains a set of factors that are assigned numerical values and combined as specified in sections 2 through 7. The factor values are rounded to the nearest integer, except where otherwise noted.

**2.1.3 Common evaluations.** Evaluations common to all four HRS pathways include:

- Characterizing sources.
  - Identifying sources (and, for the soil exposure pathway, areas of observed contamination [see section 5.0.1]).
  - Identifying hazardous substances associated with each source (or area of observed contamination).
  - Identifying hazardous substances available to a pathway.

TABLE 2-1.—SAMPLE PATHWAY SCORESHEET

Factor category	Maximum value	Value assigned
<b>Likelihood of Release</b>		
1. Observed Release .....	550	
2. Potential to Release .....	500	
3. Likelihood of Release (higher of lines 1 and 2) .....	550	
<b>Waste Characteristics</b>		
4. Toxicity/Mobility .....	(a)	
5. Hazardous Waste Quantity .....	(a)	
6. Waste Characteristics .....	100	
<b>Targets</b>		
7. Nearest Individual .....		
7a. Level I .....	50	
7b. Level II .....	45	
7c. Potential Contamination .....	20	
7d. Nearest Individual (higher of lines 7a, 7b, or 7c) .....	50	
8. Population .....		
8a. Level I .....	(b)	
8b. Level II .....	(b)	
8c. Potential Contamination .....	(b)	
8d. Total Population (lines 8a + 8b + 8c) .....	(b)	
9. Resources .....	5	
10. Sensitive Environments .....		
10a. Actual Contamination .....	(b)	
10b. Potential Contamination .....	(b)	
10c. Sensitive Environments (lines 10a + 10b) .....	(b)	
11. Targets (lines 7d + 8d + 9 + 10c) .....	(b)	
12. <b>Pathway Score</b> is the product of Likelihood of Release, Waste Characteristics, and Targets, divided by 82,500. Pathway scores are limited to a maximum of 100 points.		

\* Maximum value applies to waste characteristics category. The product of lines 4 and 5 is used in Table 2-7 to derive the value for the waste characteristics factor category.

\* There is no limit to the human population or sensitive environments factor values. However, the pathway score based solely on sensitive environments is limited to a maximum of 60 points.

- Scoring likelihood of release (or likelihood of exposure) factor category.
  - Scoring observed release (or observed contamination).
  - Scoring potential to release when there is no observed release.
- Scoring waste characteristics factor category.
  - Evaluating toxicity.
  - Combining toxicity with mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential, as appropriate to the pathway (or threat).
  - Evaluating hazardous waste quantity.
  - Combining hazardous waste quantity with the other waste characteristics factors.
  - Determining waste characteristics factor category value.
- Scoring targets factor category.
  - Determining level of contamination for targets.

These evaluations are essentially identical for the three migration pathways (ground water, surface water, and air). However, the

Section 7 specifies modifications that apply to each pathway when evaluating sites containing radioactive substances.

Section 2 focuses on evaluations common at the pathway and threat levels. Note that for the ground water and surface water migration pathways, separate scores are calculated for each aquifer (see section 3.0) and each watershed (see sections 4.1.1.3 and 4.2.1.5) when determining the pathway scores for a site. Although the evaluations in section 2 do not vary when different aquifers or watersheds are scored at a site, the specific factor values (for example, observed release,

hazardous waste quantity, toxicity/mobility) that result from these evaluations can vary by aquifer and by watershed at the site. This can occur through differences both in the specific sources and targets eligible to be evaluated for each aquifer and watershed and in whether observed releases can be established for each aquifer and watershed. Such differences in scoring at the aquifer and watershed level are addressed in sections 3 and 4, not section 2.

**2.2 Characterize sources.** Source characterization includes identification of the following:

- Sources (and areas of observed contamination) at the site.

- Hazardous substances associated with these sources (or areas of observed contamination).

- Pathways potentially threatened by these hazardous substances.

Table 2-2 presents a sample worksheet for source characterization.

**2.2.1 Identify sources.** For the three migration pathways, identify the sources at the site that contain hazardous substances. Identify the migration pathway(s) to which each source applies. For the soil exposure pathway, identify areas of observed contamination at the site (see section 5.0.1).

TABLE 2-2.—SAMPLE SOURCE CHARACTERIZATION WORKSHEET

Source: \_\_\_\_\_

A. Source dimensions and hazardous waste quantity.

Hazardous constituent quantity: \_\_\_\_\_

Hazardous wastestream quantity: \_\_\_\_\_

Volume: \_\_\_\_\_

Area: \_\_\_\_\_

Area of observed contamination: \_\_\_\_\_

B. Hazardous substances associated with the source.

[illegible]

**2.2.2 Identify hazardous substances associated with a source.** For each of the three migration pathways, consider those hazardous substances documented in a source (for example, by sampling, labels, manifests, oral or written statements) to be associated with that source when evaluating each pathway. In some instances, a hazardous substance can be documented as being present at a site (for example, by labels, manifests, oral or written statements), but the specific source(s) containing that hazardous substance cannot be documented. For the three migration pathways, in those instances when the specific source(s) cannot be documented for a hazardous substance, consider the hazardous substance to be present in each source at the site, except sources for which definitive information indicates that the hazardous substance was not or could not be present.

For an area of observed contamination in the soil exposure pathway, consider only those hazardous substances that meet the criteria for observed contamination for that area (see section 5.0.1) to be associated with that area when evaluating the pathway.

**2.2.3 Identify hazardous substances available to a pathway.** In evaluating each

migration pathway, consider the following hazardous substances available to migrate from the sources at the site to the pathway:

- Ground water migration.
  - Hazardous substances that meet the criteria for an observed release (see section 2.3) to ground water.
  - All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see section 3.1.2.1).
- Surface water migration—overland/flood component.
  - Hazardous substances that meet the criteria for an observed release to surface water in the watershed being evaluated.
  - All hazardous substances associated with a source with a surface water containment factor value greater than 0 for the watershed (see sections 4.1.2.1.2.1 and 4.1.2.1.2.2).
- Surface water migration—ground water to surface water component.
  - Hazardous substances that meet the criteria for an observed release to ground water.

- All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see sections 4.2.2.1.2 and 3.1.2.1).

- Air migration.
  - Hazardous substances that meet the criteria for an observed release to the atmosphere.
  - All gaseous hazardous substances associated with a source with a gas containment factor value greater than 0 (see section 6.1.2.1.1).
  - All particulate hazardous substances associated with a source with a particulate containment factor value greater than 0 (see section 6.1.2.2.1).

- For each migration pathway, in those instances when the specific source(s) containing the hazardous substance cannot be documented, consider that hazardous substance to be available to migrate to the pathway when it can be associated (see section 2.2.2) with at least one source having a containment factor value greater than 0 for that pathway.

In evaluating the soil exposure pathway, consider the following hazardous substances available to the pathway:



- Soil exposure—resident population threat.
  - All hazardous substances that meet the criteria for observed contamination at the site (see section 5.0.1).
- Soil exposure—nearby population threat.
  - All hazardous substances that meet the criteria for observed contamination at areas with an attractiveness/accessibility factor value greater than 0 (see section 5.2.1.1).

**2.3 Likelihood of release.** Likelihood of release is a measure of the likelihood that a waste has been or will be released to the environment. The likelihood of release factor category is assigned the maximum value of 550 for a migration pathway whenever the criteria for an observed release are met for that pathway. If the criteria for an observed release are met, do not evaluate potential to release for that pathway. When the criteria for an observed release are not met, evaluate potential to release for that pathway, with a maximum value of 500. The evaluation of potential to release varies by migration pathway (see sections 3, 4 and 6).

Establish an observed release either by direct observation of the release of a hazardous substance into the media being evaluated (for example, surface water) or by chemical analysis of samples appropriate to the pathway being evaluated (see sections 3, 4, and 6). The minimum standard to establish an observed release by chemical analysis is analytical evidence of a hazardous substance in the media significantly above the background level. Further, some portion of the release must be attributable to the site. Use the criteria in Table 2-3 as the standard for determining analytical significance. (The criteria in Table 2-3 are also used in establishing observed contamination for the soil exposure pathway, see section 5.0.1.) Separate criteria apply to radionuclides (see section 7.1.1).

TABLE 2-3.—OBSERVED RELEASE CRITERIA FOR CHEMICAL ANALYSIS

Sample Measurement < Sample Quantitation Limit*	
No observed release is established.	
Sample Measurement ≥ SAMPLE QUANTITATION LIMIT*	
An observed release is established as follows:	
• If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit.*	
• If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement is 3 times or more above the background concentration.	

\* If the sample quantitation limit (SQL) cannot be established, determined if there is an observed release as follows:

—If the sample analysis was performed under the EPA Contract Laboratory Program, use the EPA contract-required quantitation limit (CRQL) in place of the SQL.

—If the sample analysis is not performed under the EPA Contract Laboratory Program, use the detection limit (DL) in place of the SQL.

**2.4 Waste characteristics.** The waste characteristics factor category includes the following factors: hazardous waste quantity, toxicity, and as appropriate to the pathway or threat being evaluated, mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential.

**2.4.1 Selection of substance potentially posing greatest hazard.** For all pathways (and threats), select the hazardous substance potentially posing the greatest hazard for the pathway (or threat) and use that substance in evaluating the waste characteristics category of the pathway (or threat). For the three migration pathways (and threats), base the selection of this hazardous substance on the toxicity factor value for the substance, combined with its mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor values, as applicable to the migration pathway (or threat). For the soil exposure pathway, base the selection on the toxicity factor alone.

Evaluation of the toxicity factor is specified in section 2.4.1.1. Use and evaluation of the mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factors vary by pathway (or threat) and are specified under the appropriate pathway (or threat) section. Section 2.4.1.2 identifies the specific factors that are combined with toxicity in evaluating each pathway (or threat).

**2.4.1.1 Toxicity factor.** Evaluate toxicity for those hazardous substances at the site that are available to the pathway being scored. For all pathways and threats, except the surface water environmental threat, evaluate human toxicity as specified below. For the surface water environmental threat, evaluate ecosystem toxicity as specified in section 4.1.4.2.1.1.

Establish human toxicity factor values based on quantitative dose-response parameters for the following three types of toxicity:

- Cancer—Use slope factors (also referred to as cancer potency factors) combined with weight-of-evidence ratings for carcinogenicity. If a slope factor is not available for a substance, use its ED<sub>01</sub> value to estimate a slope factor as follows:

$$\text{Slope factor} = \frac{1}{6 (\text{ED}_{01})}$$

- Noncancer toxicological responses of chronic exposure—use reference dose (RfD) values.

- Noncancer toxicological responses of acute exposure—use acute toxicity parameters, such as the LD<sub>50</sub>.

Assign human toxicity factor values to a hazardous substance using Table 2-4, as follows:

- If RfD and slope factor values are both available for the hazardous substance, assign the substance a value from Table 2-4 for each. Select the higher of the two values assigned and use it as the overall toxicity factor value for the hazardous substance.
- If either an RfD or slope factor value is available, but not both, assign the hazardous substance an overall toxicity factor value from Table 2-4 based solely on the available value (RfD or slope factor).
- If neither an RfD nor slope factor value is available, assign the hazardous substance an overall toxicity factor value from Table 2-4 based solely on acute toxicity. That is, consider acute toxicity in Table 2-4 only when both RfD and slope factor values are not available.
- If neither an RfD, nor slope factor, nor acute toxicity value is available, assign the hazardous substance an overall toxicity factor value of 0 and use other hazardous substances for which information is available in evaluating the pathway.

TABLE 2-4.—TOXICITY FACTOR EVALUATION

Chronic Toxicity (Human)	
Reference dose (RfD) (mg/kg-day)	Assigned value
RfD < 0.0005	10,000
0.0005 ≤ RfD < 0.005	1,000
0.005 ≤ RfD < 0.05	100
0.05 ≤ RfD < 0.5	10
0.5 ≤ RfD	1
RfD not available	0

Carcinogenicity (Human)			
Weight-of-evidence <sup>a</sup> /slope factor (mg/kg-day) <sup>-1</sup>			Assigned value
A	B	C	
0.5 ≤ SF <sup>b</sup>	5 ≤ SF	50 ≤ SF	10,000
0.05 ≤ SF < 0.5	0.5 ≤ SF < 5	5 ≤ SF < 50	1,000
SF < 0.05	0.05 ≤ SF < 0.5	0.5 ≤ SF < 5	100
— — —	SF < 0.05	SF < 0.5	10
Slope factor not available.	Slope factor not available.	Slope factor not available.	0

\* A, B, and C refer to weight-of-evidence categories. Assign substances with a weight-of-evidence category of D (inadequate evidence of carcinogenicity) or E (evidence of lack of carcinogenicity) a value of 0 for carcinogenicity.

<sup>b</sup> SF = Slope factor.

TABLE 2-4.—TOXICITY FACTOR EVALUATION—CONCLUDED

Acute Toxicity (Human)				
Oral LD <sub>50</sub> (mg/kg)	Dermal LD <sub>50</sub> (mg/kg)	Dust or mist LC <sub>50</sub> (mg/l)	Gas or vapor LC <sub>50</sub> (ppm)	Assigned value
LD <sub>50</sub> < 5	LD <sub>50</sub> < 2	LC <sub>50</sub> < 0.2	LC <sub>50</sub> < 20	1,000
5 ≤ LD <sub>50</sub> < 50	2 ≤ LD <sub>50</sub> < 20	0.2 ≤ LC <sub>50</sub> < 2	20 ≤ LC <sub>50</sub> < 200	100
50 ≤ LD <sub>50</sub> < 500	20 ≤ LD <sub>50</sub> < 200	2 ≤ LC <sub>50</sub> < 20	200 ≤ LC <sub>50</sub> < 2,000	10
500 ≤ LD <sub>50</sub>	200 ≤ LD <sub>50</sub>	20 ≤ LC <sub>50</sub>	2,000 ≤ LC <sub>50</sub>	1
LD <sub>50</sub> not available	LD <sub>50</sub> not available	LC <sub>50</sub> not available	LC <sub>50</sub> not available	0

If a toxicity factor value of 0 is assigned to all hazardous substances available to a particular pathway (that is, insufficient toxicity data are available for evaluating all the substances), use a default value of 100 as the overall human toxicity factor value for all hazardous substances available to the pathway. For hazardous substances having usable toxicity data for multiple exposure routes (for example, inhalation and ingestion), consider all exposure routes and use the highest assigned value, regardless of exposure route, as the toxicity factor value.

For HRS purposes, assign both asbestos and lead (and its compounds) a human toxicity factor value of 10,000.

Separate criteria apply for assigning factor values for human toxicity and ecosystem toxicity for radionuclides (see sections 7.2.1 and 7.2.2).

**2.4.1.2 Hazardous substance selection.** For each hazardous substance evaluated for a migration pathway (or threat), combine the human toxicity factor value (or ecosystem toxicity factor value) for the hazardous substance with a mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor value as follows:

- Ground water migration.
  - Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 3.2.1).
- Surface water migration-overland/flood migration component.
  - Determine a combined human toxicity/persistence factor value for the hazardous substance for the drinking water threat (see section 4.1.2.2.1).
  - Determine a combined human toxicity/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.1.3.2.1).
  - Determine a combined ecosystem toxicity/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.1.4.2.1).
- Surface water migration-ground water to surface water migration component.
  - Determine a combined human toxicity/mobility/persistence factor value for the hazardous substance for the drinking water threat (see section 4.2.2.2.1).
  - Determine a combined human toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.2.3.2.1).

–Determine a combined ecosystem toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.2.4.2.1).

- Air migration.
  - Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 6.2.1).

Determine each combined factor value for a hazardous substance by multiplying the individual factor values appropriate to the pathway (or threat). For each migration pathway (or threat) being evaluated, select the hazardous substance with the highest combined factor value and use that substance in evaluating the waste characteristics factor category of the pathway (or threat).

For the soil exposure pathway, select the hazardous substance with the highest human toxicity factor value from among the substances that meet the criteria for observed contamination for the threat evaluated and use that substance in evaluating the waste characteristics factor category.

**2.4.2 Hazardous waste quantity.** Evaluate the hazardous waste quantity factor by first assigning each source (or area of observed contamination) a source hazardous waste quantity value as specified below. Sum these values to obtain the hazardous waste quantity factor value for the pathway being evaluated.

In evaluating the hazardous waste quantity factor for the three migration pathways, allocate hazardous substances and hazardous wastestreams to specific sources in the manner specified in section 2.2.2, except: consider hazardous substances and hazardous wastestreams that cannot be allocated to any specific source to constitute a separate “unallocated source” for purposes of evaluating only this factor for the three migration pathways. Do not, however, include a hazardous substance or hazardous wastestream in the unallocated source for a migration pathway if there is definitive information indicating that the substance or wastestream could only have been placed in sources with a containment factor value of 0 for that migration pathway.

In evaluating the hazardous waste quantity factor for the soil exposure pathway, allocate to each area of observed contamination only those hazardous substances that meet the criteria for observed contamination and only those hazardous wastestreams that contain hazardous substances that meet the criteria for observed contamination for that area of

observed contamination. Do not consider other hazardous substances or hazardous wastestreams at the site in evaluating this factor for the soil exposure pathway.

**2.4.2.1 Source hazardous waste quantity.** For each of the three migration pathways, assign a source hazardous waste quantity value to each source (including the unallocated source) having a containment factor value greater than 0 for the pathway being evaluated. Consider the unallocated source to have a containment factor value greater than 0 for each migration pathway.

For the soil exposure pathway, assign a source hazardous waste quantity value to each area of observed contamination, as applicable to the threat being evaluated.

For all pathways, evaluate source hazardous waste quantity using the following four measures in the following hierarchy:

- Hazardous constituent quantity.
- Hazardous wastestream quantity.
- Volume.
- Area.

For the unallocated source, use only the first two measures.

Separate criteria apply for assigning a source hazardous waste quantity value for radionuclides (see section 7.2.5).

**2.4.2.1.1 Hazardous constituent quantity.** Evaluate hazardous constituent quantity for the source (or area of observed contamination) based solely on the mass of CERCLA hazardous substances (as defined in CERCLA section 101(14), as amended) allocated to the source (or area of observed contamination), except:

- For a hazardous waste listed pursuant to section 3001 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901 et seq., determine its mass for the evaluation of this measure as follows:

–If the hazardous waste is listed solely for Hazard Code T (toxic waste), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.

–If the hazardous waste is listed for any other Hazard Code (including T plus any other Hazard Code), include the mass of the entire hazardous waste.

- For a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, determine its mass for the evaluation of this measure as follows:

- If the hazardous waste exhibits only the characteristic of toxicity (or only the characteristic of EP toxicity), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.
- If the hazardous waste exhibits any other characteristic identified under section 3001 (including any other characteristic plus the characteristic of toxicity [or the characteristic of EP toxicity]), include the mass of the entire hazardous waste.

Based on this mass, designated as C, assign a value for hazardous constituent quantity as follows:

- For the migration pathways, assign the source a value for hazardous constituent quantity using the Tier A equation of Table 2-5.
- For the soil exposure pathway, assign the area of observed contamination a value using the Tier A equation of Table 5-2 (section 5.1.2.2).

If the hazardous constituent quantity for the source (or area of observed contamination) is adequately determined (that is, the total mass of all CERCLA hazardous substances in the source and releases from the source [or in the area of observed contamination] is known or is estimated with reasonable confidence), do not evaluate the other three measures discussed below. Instead assign these other three measures a value of 0 for the source (or area of observed contamination) and proceed to section 2.4.2.1.5.

If the hazardous constituent quantity is not adequately determined, assign the source (or area of observed contamination) a value for hazardous constituent quantity based on the available data and proceed to section 2.4.2.1.2.

TABLE 2-5.—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS

Tier	Measure	Units	Equation for assigning value *
A	Hazardous constituent quantity (C)	lb	C
B *	Hazardous wastestream quantity (W)	lb	W/5,000
C *	Volume (V)		
	Landfill.....	yd <sup>3</sup>	V/2,500
	Surface impoundment.....	yd <sup>3</sup>	V/2.5
	Surface impoundment (buried/backfilled).....	yd <sup>3</sup>	V/2.5
	Drums <sup>c</sup> .....	gallon	V/500
	Tanks and containers other than drums.....	yd <sup>3</sup>	V/2.5
	Contaminated soil.....	yd <sup>3</sup>	V/2,500
	Pile.....	yd <sup>3</sup>	V/2.5
D *	Area (A)		
	Landfill.....	ft <sup>2</sup>	A/3,400
	Surface impoundment.....	ft <sup>2</sup>	A/13

TABLE 2-5.—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS—Concluded

Tier	Measure	Units	Equation for assigning value *
	Surface impoundment (buried/backfilled).....	ft <sup>2</sup>	A/13
	Land treatment.....	ft <sup>2</sup>	A/270
	Pile.....	ft <sup>2</sup>	A/13
	Contaminated soil.....	ft <sup>2</sup>	A/34,000

- \* Do not round to nearest integer.
- <sup>b</sup> Convert volume to mass when necessary: 1 ton=2,000 pounds=1 cubic yard=4 drums=200 gallons.
- <sup>c</sup> If actual volume of drums is unavailable, assume 1 drum=50 gallons.
- <sup>d</sup> Use land surface area under pile, not surface area of pile.

**2.4.2.1.2 Hazardous wastestream quantity.** Evaluate hazardous wastestream quantity for the source (or area of observed contamination) based on the mass of hazardous wastestreams plus the mass of any additional CERCLA pollutants and contaminants (as defined in CERCLA section 101[33], as amended) that are allocated to the source (or area of observed contamination). For a wastestream that consists solely of a hazardous waste listed pursuant to section 3001 of RCRA, as amended or that consists solely of a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, include the mass of that entire hazardous waste in the evaluation of this measure.

Based on this mass, designated as W, assign a value for hazardous wastestream quantity as follows:

- For the migration pathways, assign the source a value for hazardous wastestream quantity using the Tier B equation of Table 2-5.
- For the soil exposure pathway, assign the area of observed contamination a value using the Tier B equation of Table 5-2 (section 5.1.2.2).

Do not evaluate the volume and area measures described below if the source is the unallocated source or if the following condition applies:

- The hazardous wastestream quantity for the source (or area of observed contamination) is adequately determined—that is, total mass of all hazardous wastestreams and CERCLA pollutants and contaminants for the source and releases from the source (or for the area of observed contamination) is known or is estimated with reasonable confidence.

If the source is the unallocated source or if this condition applies, assign the volume and area measures a value of 0 for the source (or area of observed contamination) and proceed to section 2.4.2.1.5. Otherwise, assign the source (or area of observed contamination) a value for hazardous wastestream quantity based on the available data and proceed to section 2.4.2.1.3.

**2.4.2.1.3 Volume.** Evaluate the volume measure using the volume of the source (or the volume of the area of observed

contamination). For the soil exposure pathway, restrict the use of the volume measure to those areas of observed contamination specified in section 5.1.2.2.

Based on the volume, designated as V, assign a value to the volume measure as follows:

- For the migration pathways, assign the source a value for volume using the appropriate Tier C equation of Table 2-5.
- For the soil exposure pathway, assign the area of observed contamination a value for volume using the appropriate Tier C equation of Table 5-2 (section 5.1.2.2).

If the volume of the source (or volume of the area of observed contamination, if applicable) can be determined, do not evaluate the area measure. Instead, assign the area measure a value of 0 and proceed to section 2.4.2.1.5. If the volume cannot be determined (or is not applicable for the soil exposure pathway), assign the source (or area of observed contamination) a value of 0 for the volume measure and proceed to section 2.4.2.1.4.

**2.4.2.1.4 Area.** Evaluate the area measure using the area of the source (or the area of the area of observed contamination). Based on this area, designated as A, assign a value to the area measure as follows:

- For the migration pathways, assign the source a value for area using the appropriate Tier D equation of Table 2-5.
- For the soil exposure pathway, assign the area of observed contamination a value for area using the appropriate Tier D equation of Table 5-2 (section 5.1.2.2).

**2.4.2.1.5 Calculation of source hazardous waste quantity value.** Select the highest of the values assigned to the source (or area of observed contamination) for the hazardous constituent quantity, hazardous wastestream quantity, volume, and area measures. Assign this value as the source hazardous waste quantity value. Do not round to the nearest integer.

**2.4.2.2 Calculation of hazardous waste quantity factor value.** Sum the source hazardous waste quantity values assigned to all sources (including the unallocated source) or areas of observed contamination for the pathway being evaluated and round this sum to the nearest integer, except: if the sum is greater than 0, but less than 1, round it to 1. Based on this value, select a hazardous waste quantity factor value for the pathway from Table 2-6.

TABLE 2-6.—HAZARDOUS WASTE QUANTITY FACTOR VALUES

Hazardous waste quantity value	Assigned value
0.....	0
1* to 100.....	1*
Greater than 100 to 10,000.....	100
Greater than 10,000 to 1,000,000.....	10,000
Greater than 1,000,000.....	1,000,000

\* If the hazardous waste quantity value is greater than 0, but less than 1, round it to 1 as specified in text.

\* For the pathway, if hazardous constituent quantity is not adequately determined, assign a value as specified in the text; do not assign the value of 1.



For a migration pathway, if the hazardous constituent quantity is adequately determined (see section 2.4.2.1.1) for all sources (or all portions of sources and releases remaining after a removal action), assign the value from Table 2-6 as the hazardous waste quantity factor value for the pathway. If the hazardous constituent quantity is not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action) assign a factor value as follows:

- If any target for that migration pathway is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2-6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway.

- If none of the targets for that pathway is subject to Level I or Level II concentrations, assign a factor value as follows:

- If there has been no removal action, assign either the value from Table 2-6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value for that pathway.

- If there has been a removal action:

- Determine values from Table 2-6 with and without consideration of the removal action.

- If the value that would be assigned from Table 2-6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2-6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the pathway.

- If the value that would be assigned from Table 2-6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the pathway.

For the soil exposure pathway, if the hazardous constituent quantity is adequately determined for all areas of observed contamination, assign the value from Table 2-6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed contamination, assign either the value from Table 2-6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

**2.4.3 Waste characteristics factor category value.** Determine the waste characteristics factor category value as specified in section 2.4.3.1 for all pathways and threats, except the surface water-human food chain threat and the surface water-environmental threat. Determine the waste characteristics factor category value for these latter two threats as specified in section 2.4.3.2.

**2.4.3.1 Factor category value.** For the pathway (or threat) being evaluated, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to a maximum product of  $1 \times 10^6$ . Based on this waste characteristics product assign a waste characteristics factor

category value to the pathway (or threat) from Table 2-7.

TABLE 2-7.—WASTE CHARACTERISTICS FACTOR CATEGORY VALUES

Waste characteristics product	Assigned value
0	0
Greater than 0 to less than 10	1
10 to less than $1 \times 10^2$	2
$1 \times 10^2$ to less than $1 \times 10^3$	3
$1 \times 10^3$ to less than $1 \times 10^4$	6
$1 \times 10^4$ to less than $1 \times 10^5$	10
$1 \times 10^5$ to less than $1 \times 10^6$	18
$1 \times 10^6$ to less than $1 \times 10^7$	32
$1 \times 10^7$ to less than $1 \times 10^8$	56
$1 \times 10^8$ to less than $1 \times 10^9$	100
$1 \times 10^9$ to less than $1 \times 10^{10}$	180
$1 \times 10^{10}$ to less than $1 \times 10^{11}$	320
$1 \times 10^{11}$ to less than $1 \times 10^{12}$	560
$1 \times 10^{12}$	1,000

**2.4.3.2 Factor category value, considering bioaccumulation potential.** For the surface water-human food chain threat and the surface water-environmental threat, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to:

- A maximum product of  $1 \times 10^{12}$ , and
- A maximum product exclusive of the bioaccumulation (or ecosystem bioaccumulation) potential factor of  $1 \times 10^6$ .

Based on the total waste characteristics product, assign a waste characteristics factor category value to these threats from Table 2-7.

#### 2.5 Targets.

The types of targets evaluated include the following:

- Individual (factor name varies by pathway and threat).
- Human population.
- Resources (these vary by pathway and threat).

- Sensitive environments (included for all pathways except ground water migration).

The factor values that may be assigned to each type of target have the same range for each pathway for which that type of target is evaluated. The factor value for most types of targets depends on whether the target is subject to actual or potential contamination for the pathway and whether the actual contamination is Level I or Level II:

- Actual contamination: Target is associated either with a sampling location that meets the criteria for an observed release (or observed contamination) for the pathway or with an observed release based on direct observation for the pathway (additional criteria apply for establishing actual contamination for the human food chain threat in the surface water migration pathway, see sections 4.1.3.3 and 4.2.3.3), sections 3 through 6 specify how to determine the targets associated with a sampling location or with an observed release based on direct observation. Determine whether the actual contamination is Level I or Level II as follows:

- Level I:

- Media-specific concentrations for the target meet the criteria for an

observed release (or observed contamination) for the pathway and are at or above media-specific benchmark values. These benchmark values (see section 2.5.2) include both screening concentrations and concentrations specified in regulatory limits (such as Maximum Contaminant Level (MCL) values), or

- For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms are at or above benchmark values. Such tissue samples may be used in addition to media-specific concentrations only as specified in sections 4.1.3.3 and 4.2.3.3.

- Level II:

- Media-specific concentrations for the target meet the criteria for an observed release (or observed contamination) for the pathway, but are less than media-specific benchmarks. If none of the hazardous substances eligible to be evaluated for the sampling location has an applicable benchmark, assign Level II to the actual contamination at the sampling location, or

- For observed releases based on direct observation, assign Level II to targets as specified in sections 3, 4, and 6, or

- For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms, when applicable, are below benchmark values.

- If a target is subject to both Level I and Level II concentrations for a pathway (or threat), evaluate the target using Level I concentrations for that pathway (or threat).

- Potential contamination: Target is subject to a potential release (that is, target is not associated with actual contamination for that pathway or threat).

Assign a factor value for individual risk as follows (select the highest value that applies to the pathway or threat):

- 50 points if any individual is exposed to Level I concentrations.
- 45 points if any individual is exposed to Level II concentrations.

- Maximum of 20 points if any individual is subject to potential contamination. The value assigned is 20 multiplied by the distance or dilution weight appropriate to the pathway.

Assign factor values for population and sensitive environments as follows:

- Sum Level I targets and multiply by 10. (Level I is not used for sensitive environments in the soil exposure and air migration pathways.)
- Sum Level II targets.
- Multiply potential targets by distance or dilution weights appropriate to the pathway, sum, and divide by 10. Distance or dilution weighting accounts for diminishing exposure